REPORT ON THE OUTBREAK OF BLISTER BLIGHT ON TEA IN THE DARJEELING DISTRICT IN 1908-1909.

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PLATE I.

Report on the Outbreak of Blister Blight on Tea in the Darjeeling District

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THIS report is the result of two tours in the Darjeeling district in the months of July and September of 1909. It simply presents the problem to be faced there, touches on some of the lines of investigation and indicates the means of dealing with the blight during the cold weather of 1909-1910. Early in June 1908 leaves of the tea plant affected with blister blight (Exobasidium vexans, Massee) were noticed on heavy pruned Assam tea bushes on Pullongdong and a few days later on pruned tea on Pubong and Pussimbing. Early in September the first trace of it was seen on the adjacent garden of Tongsong and a week later it had spread over the neighbouring gardens. The first public discussion took place at the Planters' Association Meeting in Darjeeling at the end of September, when in the crop telegram was inserted "Blister blight is generally severe and is checking leaf." At Tukvar it was noticed early in October and almost certainly existed unnoticed on other gardens in this part of the district. Starting late in the season the blight did not do much damage, though sufficient to make planters keep a keen look out during the following season for its reappearance. In November when the growth of the bushes stopped the blight died off and during the cold weather disappeared.

This was the first appearance of blister blight observed and recorded in the district of Darjeeling. It is not, however, a new blight on the tea-plant but hitherto has been confined to the upper part of the Brahmaputra Valley in north-eastern Assam. These two places are widely separated yet the blight does not seem to have been reported from any of the intervening tea districts of Cachar, Sylhet or the Duars. This blight was investigated in Upper Assam by Sir George Watt*

* Pests and Blights of the Tea Plant. G. Watt. 1898. Page 119 onwards.

about 1895 and from material sent by him to Kew the fungus causing the disease was described and named by Massee.*

In 1909 the blight appeared on the same gardens, but earlier in the season, *viz.*, in March on Negali on heavy pruned Assam bushes when the leaves were just sprouting, in June on Dooteriah Division on Assam bushes two years away from heavy pruning and cut back to one eye, and about the end of June on Tukvar on China jât which had been heavy pruned. Though the Manager of Tukvar Garden first discovered the blight on a bush of Assam tea cut back to one eye, yet from his observations during the next few days on the prevalency of the blight in the garden it is most probable that the blight came first on heavy pruned China tea. During the summer it made its appearance on several neighbouring gardens. On all it spread rapidly and gradually extended, till hardly a garden in this part of the district is now free from blister blight.

The first indication of a blister is a small, pale green, pale yellow, or pinkish, translucent spot, easily seen against the darker green of the rest of the leaf when it is held up to the light. Sometimes the pinkish tinge fades or it may never be discernible. In other cases the spot is deep red on both sides like red ink, and the red tinge remains even when the spores are ripe. Plate I, fig. 2. The circular spot enlarges, usually reaching a diameter of 5 to 15 mm. but sometimes as much as 23 mm. On the upper side of the leaf the spot becomes gradually depressed into a shallow cavity and on the under side it bulges out slightly, thus forming the blister from which the blight takes its name. Plate I, fig. 1. The upper, concave, circular area is smooth and shiny as if it had been touched with varnish and still remained wet and the colour is usually paler green than the rest of the leaf, often with a yellowish or reddish tinge and sometimes deep red. The under convex surface, on the other hand, remains dull and assumes a grey look as if dusted with white powder and, when mature, becomes pure white, downy, and quite dry. The lower surface produces colourless spores which, with the outgrowth of the fungus filaments, give the white appearance to the under side of the blister and on some vigorous, rapidly growing blisters slightly also to the upper side. In not a few cases the form of blister is reversed and both forms may be found on the same leaf. Then it is concave on the lower side of the leaf and bulged out on the upper, but the white spore-

* Kew Gardens Bulletin. 1898. Tea Blights. G. Massee. Pages 109-111.

bearing surface is always principally on the under side of the leaf. Gradually the white surface becomes discoloured till at last it is dark brown or almost black, and the blistered spot becomes dry and crinkled and shrinks so that the depressed blister disappears and the discoloured circular patch is in the same plane as the rest of the leaf surface. Only fresh young leaves and buds are liable to infection. When a leaf is over four weeks old it is past the stage at which it may be infected.

After the leaves of a bush have been attacked the disease spreads to the leaf-stalks and the young, succulent, green stems, Plate I, figs. 1, 2, 3, but here the appearance of the disease is not so conspicuous though the damage is much more serious. The course of the disease on the young delicate stem is like that on the leaf only no blister is formed. The colour of the young spot is very similar but the deep crimson tinge is not present. The spot, circular at first, soon becomes elongated in the direction of the stem-axis and gradually spreads round the stem. The affected area is slightly swollen and when the spot surrounds a node the diameter of the stem at that place may be twice as much as that of the unattacked portion above or below. When the spore-bearing filaments break through the epidermis they give a grey appearance to the spot but it does not always become dead-white like the blister. The disease eats through the stem so that the leaves and buds above wither and blacken and the stem bends over at the diseased part, Plate III. When there are several of these dead twigs on a bush they give it a black decaying unsightly appearance. Whether the mycelium is perennial in the branches and produces the first crop of spores in the following season I have had no opportunity of observing yet but will try to find out next spring.

In a section of a translucent spot the cells of the leaf-tissue are seen to contain chloroplasts less deeply coloured with chlorophyll than those in undiseased portions of the leaf, thus accounting for the paleness in colour, and the cell-sap contains a pinkish liquid which gives the colour to the young spot. Little or no starch is present in these cells, contrary to what is found in the cells of the undiseased portion of a leaf. The filaments or hyphae of the fungus are seen ramifying between the cells of the host-plant. In sections of mature spots one sees that the cells of the spongy parenchyma have increased in number more rapidly than those of the palisade layer. The filaments too crowd together in masses on the inner side of the lower epidermis so that the cells of the spongy paren-

chyma of the host-leaf become pushed apart and isolated. The tension thus caused between the two unequally expanding layers and the unyielding healthy tissue on the margin causes the spot to bulge out into the form already described. The filaments are very thin, 1·5 to 2·3 μ in diameter, and septate. Little groups of filaments are pushed through the stomata and bear spores and the hyphal masses below the epidermis increase so fast that, almost immediately, the latter is ruptured in many places and little tufts of hyphæ break through till at length they are so numerous that they form an almost continuous plane of hyphæ giving the white woolly appearance to the spot. These hyphæ bear two kinds of spores.

1. By far the most abundant are two-celled conidia each at the end of a long stalk. They vary from 12 to 21 μ in length and 1·5 to 6·0 μ in breadth.

2. Basidia are borne here and there on the surface in fairly large numbers but never so close as to form a continuous surface of basidia. They are long and club-shaped, usually producing two short sterigmata, each of which supports a basidiospore. The basidia are 30 to 48 μ or even up to 90 μ long by 3·7 to 6 μ broad, and the sterigmata are 3 to 5 μ long. Four spores on a basidium have not been observed though many sections were examined but on one basidium three sterigmata and on three others four sterigmata were clearly seen. The basidium according to Massee contains four nuclei, so may occasionally produce four basidiospores, two at a time or all at once. The spores are colourless and elliptical, 7·1 to 13·6 μ long and 2·3 to 4·5 μ broad, the average being 10 × 3·2 μ. Massee* gives the basidiospores as 5 × 3 μ. The measurements here given are from forty basidiospores, each of which was attached by its sterigma to a basidium. The sections were cut from freshly gathered leaves, mounted in water and immediately measured. Besides these many of the filaments are barren and run out beyond the surface level, giving the downy appearance to the spot. In a vigorously growing blister the upper epidermis may also be broken through and bear spores in a similar way but they are always comparatively few in number.

When kept in a moist chamber on a glass slide or on the surface of a tea leaf, spores swell slightly and germinate within 5½ hours of being

* Massee, G. Tea Blights. Kew Gardens Bulletin, 1898, p. 111.

sown. From each of the two cells of a conidium a germ-tube may be produced. Some of the conidia, being one-celled only, are difficult to distinguish with certainty from basidiospores when both are lying isolated. Some one-celled conidia develop a transverse wall before germination and are thus easily distinguishable yet all do not, and it is difficult to separate basidiospores with certainty as they are so few in number and the conidia are so numerous. They germinate, however, *in situ* so that the germination of both one-celled conidia and of basidiospores has been observed and the phenomena are similar. The germ-tubes grow in length and enter the leaf by the stomata. Once inside they branch and ramify between the cells, chiefly in the spongy parenchyma, ultimately giving rise just under the lower epidermis to the dense masses of mycelium which produce the spore-bearing hyphae. The germ-tube may not enter by the first stoma it passes near and may branch before it enters. Stomata are present only on the under side of the leaf hence it is on this surface that infection takes place. Several successful inoculations were made in the field on young shoots protected under Erlenmeyer flasks and also on cut shoots kept in water under a bell jar. After a period of eleven days the translucent spot is clearly visible and in from six to eight days later the blister is formed and filaments are producing spores. The period between inoculation and the maturity of the blister varies greatly according to weather conditions and is shortest in hot, moist, cloudy weather.

If a blister is situated on the midrib the leaf often folds, or rolls upon itself irregularly, sometimes the lower and sometimes the upper surface of the leaf remaining outermost. If the blister is near the margin, the leaf may become curled, Plate I, fig. 3, and if there are several it becomes twisted in the most fantastic manner. On a young leaf the blister sometimes appears on or near the petiole and then, besides being twisted, the leaf remains stunted. Frequently too a blister occurs just below the tip of the leaf. Blisters that come on the midrib have often an irregular outline, spreading lengthwise more easily than across the leaf.

The number of blisters on a leaf varies from one up to about twenty and they may be isolated or several may run together to form a large patch with an irregular outline. To such an extent does this sometimes go that the whole under surface of the leaf may be covered with an even mass of coalescing blisters.

If only one or two blisters occur on a leaf its efficiency is not much impaired. When, however, many of the leaves are blistered the damage done to a bush in reducing its green surface available for food-making is very great and in addition the parasite is draining its host of the nourishment made for it by healthy leaf tissue. When the vitality of the plant is lowered the healthy flushing of the young leaves is retarded thus causing considerable loss. After the disease has run unchecked through a bush and the young shoots have fallen over and decayed, it has a black unsightly appearance quite justifying the anxiety of the managers on those gardens where the disease is prevalent.

The exact spot in the district where the disease originated cannot be settled with certainty but it was most probably on the slopes on the southern side of the Senchal ridge. Last year it was noticed at several places near the head waters of the Balasan river almost simultaneously and after it had once been reported it was found on quite a number of gardens. From this it may be conjectured that the rate of dissemination of the disease was very rapid or that it may have existed in the gardens for some time without having been noticed. This last may quite well have occurred in gardens where it was doing little real damage especially as the disease was new to the district and was then unknown to many planters. From observations made this year the former also does seem to be the case and when once the blisters have matured, the spores which they produce quickly become distributed.

When blister blight appears on a block it runs its course somewhat after this manner. Here and there several bushes are badly affected, and scattered bushes, more or less numerous, are slightly affected. Not every bush even in a badly affected block, is attacked. Certain bushes often seem to be resistant to the disease and remain healthy and free from blight even though their neighbours are suffering severely. Only one or two leaves on a bush may be blistered or there may be a few or a great many. A block may appear to be quite healthy and then suddenly a few blistered leaves may be seen scattered throughout it and this frequently occurs in a noticeable way when, after a few days' sunshine, a spell of wet weather recurs. Little harm may be done and the damage may end there or the blight may become worse and worse, both mature leaves and young shoots becoming affected, then blackening and dying till leaf-picking is stopped. It does not seem to begin in one place and gradually spread round in widening circles

but to come quite erratically and spread very quickly. In one case (Kalagé), it spread from a low elevation to the upper parts of the garden and in another (Kodong) it as certainly spread from above downwards and other examples might be quoted both ways. The spores of the parasite are distributed by the wind, and the sudden attack can be understood when one remembers the fairly strong breezes that sometimes blow upwards from the valleys and anon downwards over the ridges. On days in which there are a few hours of dry weather or sunshine the wind will blow the light, dry, powdery spores about, and they might be borne a considerable way and scattered over a comparatively wide area. In the Balasan valley strong breezes blow up the valley, especially in the evening of a hot day, and the disease has travelled much more rapidly and is more severe towards the head waters, than downwards towards the plains. In this valley the disease is severe on slopes exposed to the wind, *i.e.*, on southern slopes. On the Tukvar side of Senchal the winds are not so steady and are more irregular and here the distribution of the disease is erratic. As the coolies are picking leaf their clothes must often brush off spores from affected leaves and carry them to leaves on neighbouring bushes. This is, probably, a common means of distribution within the limits of a garden.

Shade whether artificial from planted trees or from proximity to the jungle favours the blight and it is worse too on low, damp, shady hollows. It was frequently found that the bushes under the trees grown for shade in the garden were affected when the surrounding unshaded bushes were free from blight and when both were affected the shaded bushes were more severely blistered. This occurred chiefly under older trees that had become so dense as to be affording more than the optimum amount of shade, and suggests the thinning of the jungle trees near the tea and lopping off branches where shade-trees have become too dense. Bushes that had been lightly picked in order to strengthen them were occasionally the worst attacked in a block. This was rather strikingly noticeable in one garden where bushes that were being saved were marked by a bamboo stake. The stake was almost a certain indication of a badly blistered bush. This is because in light picking much succulent leaf is left on the bush giving a greater amount of suitable surface for the blight to work on. Still it may be that in spite of blister the bushes gained more by being spared than they lost because of the disease.

The blight attacks the high quality Assam and hybrid jâts most severely, while China and Manipuri are not so much affected. It is quite interesting to see, in some China blocks where Assam or hybrid bushes have been used to refill empty places, how the leaves of the two high quality jâts are well infected with blister whereas the leaves of the China are almost free. Yet in some gardens China jât is very badly affected and bushes have a woeful white or black appearance according to the stage of the disease.

With regard to unpruned, lightly pruned, and heavily pruned tea I cannot definitely say that one is attacked more often than another but it is quite plain that the amount of harm done, when once the blight has come on them, is inversely as the order in which they are mentioned. In the young, succulent, quickly-growing leaves of heavy pruned bushes the blight develops very vigorously and may destroy nearly all the leaves. Now the productiveness for the next few years of bushes that have been heavy pruned depends on the formation of a good frame work of good bearing wood in the first season after heavy pruning. To make this new wood, the health of the young green leaves is vital and any blight which reduces their efficiency, as blister blight does, causes not only serious damage in the year of attack but serious loss in the crop of succeeding years.

The blight is severe on areas with a high rain-fall and worse about that elevation where rain falls nearly every day during the monsoon and mists hang about, lifting only at rare intervals. Thus on the ridges and slopes in the Rungbang and Balasan valleys, whose waters drain towards the plains, the blight is on the whole worse than on the gardens on the Darjeeling side of Senchal. The continued dampness of much of the Darjeeling district in the rains is most favourable to the blight and, as such weather conditions come every year, it is possible that the blight may be more difficult to deal with here than elsewhere. This should be kept in mind when comparing with the experience of planters in the Brahmaputra Valley where a season as wet as that annually occurring in Darjeeling comes less frequently.

As to the severity of the attack of 1908 and 1909 in relation to elevation, the evidence points to the blight being more severe at high elevation and worst between 4,000 and 5,500 feet. Elevation is not the real factor with regard to severity but moisture, for in this district high elevation means, within certain limits, high and evenly distributed

rainfall during the monsoon. The three worst blocks and the only extremely bad cases on a large area seen by me in July were at a high elevation, *viz.*, 70 acres of one-eye pruning and 10 acres of heavy pruning mostly Assam jât between 5,000 and 5,400 feet, 40 acres of heavy pruning of two years old mostly China jât between 5,000 and 5,300 feet and in September 20 acres of heavy pruning of Assam jât between 5,200 and 5,500 feet. On a single garden of low elevation in the Rangit valley where the rainfall is very small the blight came late in the season of 1909 and was only very slight; one had to search carefully to get blistered leaves, but during October it spread very considerably and some bushes were white with it nearly all over. It has also been noticed elsewhere at 1,200 feet. It has extended southwards as far as Gayabari garden which abuts on the plains. There is then a grave danger of its spreading downwards to the plains.

The amount of damage done by blister blight this season is difficult to gauge. Compared with the total output of tea in the affected gardens the loss this year from blister blight is small. But it would be unwise to conclude that what the blight has done in its first season in the district is a measure of what it can do. Fortunately for the industry weather conditions were favourable from April to June and gardens flushed well getting thus well ahead of their usual average. They have, however, since gone down and some gardens are well behind. A large part of the loss is attributable to wet, unfavourable weather in July and August but a considerable portion is due to blister blight. The worst damaged piece of tea was an area of 20 acres of last year's heavy pruning on a high jât garden. It was literally ruined, 90 per cent. of the bushes having nearly all the leaves blistered or fallen off and the bare stems had the discoloured marks of the blight where the shoots were attacked and the upper parts had fallen off. Even young buds pushing out from the leafless branches were blistered and to such an extent that the young leaves of the buds were stunted and red or blackened according to the stage of the disease. This is a good example of what the blight can do when once it gets a good grip of a block of heavy-pruned tea. So far as the growth for this year is concerned there is little or none. Most of the bushes will start next season as if they had just been heavy pruned unless, as is more likely to be the case, they start weakened by the loss of a season's growth. In new extensions the young plants often suffer badly. In Plate I, figs. 4 and 5, are a couple of

seedlings with in one case all the leaves blistered and in the other all the leaves dead through blister blight. It attacks, too, young buds just bursting open, the tender leaves become covered with blisters thus stopping development and killing off the buds. On Dooteriah, Sunnipani, and Tongsong gardens comprising about 1,300 acres of tea under one Manager the amount of blistered leaves gathered and destroyed in the two seasons amounted to 903 maunds. About $\frac{5}{6}$ of this was growth-leaf which would not be made into tea and the other $\frac{1}{6}$ represented loss of leaf that would have produced tea, *i.e.*, about 37½ maunds (3,000 lbs. of manufactured tea. The cost of collecting this amount of blistered leaf was 657 rupees (£43-16-0) which also represents loss. At Tukvar the loss this year from blister blight is about 30 maunds of tea (2,400 lbs. These two are taken as average examples of loss in crop and some gardens have much greater or much less loss. On Pussimbing and Kodong gardens the loss last year was put down as 50 maunds (4,000 lbs. of tea and the estimated loss for this year is 100 maunds. This is more than has been lost in any other garden in the hills. In one garden the whole of the seedlings were destroyed by blister blight. The seed was high jât Assam contaminated by a little low class jât. Almost all the seedlings of the former were killed off, while only a few of the latter had survived till September. The cost of seed and upkeep of this seed-bed for the season amounted to 770 rupees (£51). These are tangible examples of loss due to blister blight but no account has been taken of the damage due to the lowering of tone and weakening of the bushes.

How blister blight came to the tea-plant in this district is not at all apparent. There are at least two possibilities of its origin. It may have come from a jungle plant or from material imported from the Brahmaputra Valley. During the last few years no plants, as far as can be ascertained, have been procured from this region. Every year small quantities of seed have been imported into Darjeeling district from various places in Assam and especially from Dibrugarh and the surrounding tea area where some of the best tea-seed is grown. It is possible that spores may have been introduced with the seed or the earth in which it is usually packed. No definite experiments, however, have been made on the longevity of the spores or the mycelium of the fungus causing blister blight. The evidence for the introduction of the blight in this way is not conclusive. The blight, on the other hand, may have come from the jungle. Opinions differ as to the

observed presence of the disease on jungle trees. Some believe it did not exist in the jungle but other planters maintain that they have observed the disease on jungle trees for many years. A careful search was made in July and September 1909 among the weeds and trees on the gardens and on the edge of the jungle but, though many spotted and blistered leaves were examined, none were found to have been caused by the same fungus (*Exobasidium vexans*) as causes blister blight of tea. Blistered leaves very like those on tea plants were found first at Pubong, then at Dooteriah, on Kharani (Symplocos Theæfolia, D. Don), Plate IV. The parasitic fungus is not Exobasidium vexans but a new species of Exobasidium which remains to be described. Some inoculations made on tea shoots with the spores from the Kharani fungus were not successful. Near Tukvar leaves with brown blisters, in form somewhat like the white blisters on tea, were also found on two kinds of jungle trees but both were due to insect attack. Such have been shown and sent to me several times as samples of blister blight on jungle trees. Needless to say they have no connection whatever with blister blight on tea.

Mr. E. J. Webb believes he has noticed blister blight on jungle trees other than that just mentioned, *viz.*, on arkhaula (*Quercus spicata*, Sm., chilauni (*Nyssa sessiliflora*, Hk. f.) lepchaphul (*Machilus edulis*, King.), kawala or kaunla (*Machilus Gamblei*, King.), and kuttoos (chestnut). Specimens of blisters on any of these trees were not available in the middle of July as the blight had then disappeared from the jungle. Jungle chaukidars might be shown the disease on tea and told to keep a look out for similar appearances on jungle plants and the Imperial Mycologist will always be glad to examine material of any kind sent to Pusa. Massee mentions *Rhododendron*, *Vaccinium*, *Andromeda*, *Cassandra*, *Arctostaphylos*, *Ledum*, *Saxifraga*, *Laurus*, *Symplocos*, *Arthrocatheum*, and *Bromus* as host plants of the genus Exobasidium and Mann* mentions the garden Croton (*Codiæum variegatum*, Blume.), and mahor (*Mesua ferrea*, Linn.) as possible hosts of Exobasidium vexans. It is most unlikely that it will be found on all of these plants but it may occur on one or two. Exobasidia are, as a rule, restricted in the number of common host plants. At any rate there is some reason for the presumption that the parasite existed in past years on some species of tree in the jungle and that it has thence spread to the tea plant. Why, however, it did not spread to tea bushes within the last forty years is an

* Mann, H. H. The Blister Blight of Tea. Indian Tea Association Bulletin 3. 1906.

enigma. It is very important to settle this point and next season as thorough a search as possible should be made in the jungle to try to discover whether there really is another host plant.

In Assam, where the disease has been present for the last forty years at least, the occurrence of the disease as an epidemic is regulated by climatic conditions still unknown. There the disease comes apparently erratically on an area which may be large or small, runs its course for some months, killing off new shoots and leaves and then the bushes gradually recover. I believe that now little anxiety is felt with regard to the disease and little is done to combat it. One year it spreads with remarkable rapidity over a garden and next year may be almost entirely absent. There is at least indication of this too in the Darjeeling district where in several places a small area affected last year showed no trace of a blistered leaf this year. This is a hopeful circumstance in the course of the disease and we trust it may be made manifest in the coming year.

Methods that have been tried for keeping the disease in check. They resolve themselves into

(1) picking off diseased material
(2) pruning
(3) spraying with fungicides.

The first and second aim at lessening the spread of the disease by removing and destroying the leaves and stems bearing the spores which are the reproductive bodies of the parasite and which cause new infection on other leaves and shoots. The third aims at destroying the fungus and at preventing the growth of the spores that have fallen or may fall on the sprayed leaves.

In Dooteriah division, since the first appearance of the blight in September 1908, and in the season of 1909, when the blight was very generally distributed in this garden, the Manager has had blistered leaves and shoots picked off and destroyed. Of course it was understood that plucking off blistered leaves would not eradicate the disease. The most that was expected was that it would lessen the spread of the blight by destroying the material that was producing the spores for its dispersal. It was hoped, however, that destroying blistered leaves and shoots in not very badly affected areas might have been sufficient to check the blight.

It was recognised that there was a grave danger in letting coolies go indiscriminately over the tea picking blistered leaves. Their hands, clothes and baskets were bound to get spores on them and these spores would be rubbed on healthy leaves. The coolies, then, told off to pluck for blister were not allowed to pick for tea. Nor were the baskets that had contained blighted leaves used for holding leaf for tea. It was thought advisable that they should put a handful of damp grass in the bottom of the basket and another on top when they were bringing it to the place for destroying the leaves. This was to prevent the leaves drying up and the powdery spores from being shaken or blown out of the basket. The baskets of blistered leaves when being examined at noon or in the evening were looked at to see that only blistered leaves were taken and not spotted leaves as well, which spots were not caused by the blister fungus. Discrimination was exercised, too, in destroying the blistered leaves and before the coolies began picking, it was decided what to do with the gathered material. From blocks near the factory the leaves were burned in the furnace but on distant areas it was thought better to bury them in trenches near the place where they were picked, taking care that they were buried deep enough and in a place where heavy rain would not wash off the surface soil and re-expose them. The chance of spreading the spores while transporting the baskets to the factory was thus eliminated, while the tea near the trenches did not become affected more than that anywhere else. This practice is not without its dangers. Earthworms and crickets may bring up the buried material to the surface in their castings or jackals may scratch off the earth. The best plan is to burn the blistered leaves and prunings on the spot. Though affected leaves had been unintermittently pulled off and destroyed yet after the beginning of August the blight spread more rapidly than it could be coped with and during the month got beyond the available labour for treating it in this way. In all about 620 maunds of blistered leaves were destroyed this season. This shows that though the work of plucking blistered leaves in a garden be prosecuted with energy from the time it first appears yet the blight may get a good hold and get out of control. Though the blight be kept in check for a time yet the result is not satisfactory.

At Pussimbing the Manager tried to check the blight by close plucking. He chose a fairly badly affected block of about sixteen acres and removed from all the bushes in this block all blistered leaves,

young shoots and sprouting buds whether affected with blight or not. This was repeated three times at intervals of four or five days so that the fourth picking was done about fourteen days after the first. The shoots were then allowed to grow and the new leaves and stems came away healthy and unblistered. The idea underlying this treatment is that the spores infect young, soft leaves not long emerged from the bud and that a period of about ten days elapses between infection and the first appearance on a leaf of the pale spot which is the first visible indication of what is about to become a blister and produce spores. If all such young leaves and stems, that have or may have been infected, be continually plucked off within this time then the production of spores will be checked and the young shoots will presumably grow up free from blight.

An adjacent block in the same garden had the blistered leaves and the buds all picked off once. The blight was temporarily checked but, when the new flush came, many leaves were blistered. This treatment alone is not of much avail. It must be mentioned that the first block was not entirely free from blister. On searching, a few blistered leaves could still be found especially near a road dividing this block from an upper one also infected and the probability is that some of these few leaves were missed by the coolies and some were reinfected from this neighbouring block which had not been treated in the same way. This shows the possibility of work on one block being partially annulled by reinfection from another and one must remember too that much depends upon the efficiency and carefulness of the coolies who are picking.

This course, however, seemed to be so successful that it was tried on a larger scale on the same garden and finally with a slight modification was adopted as the method of picking throughout the whole garden. After making one picking as above the coolies got round the garden once every eight to ten days. They took a bud and two leaves as usual, but removed the 3rd leaf as well as the 4th if there was one. Little shoots with only a bud and one leaf were left. So far as the absence of blister blight is concerned the result on Pussimbing and especially on Pulong was very satisfactory. In July when the treatment was begun the blight was very common on both gardens and severe on part of the latter. By the middle of September there was not much blight on either garden.

Similarly on another garden where a system of fairly close picking was in vogue, it was noticed that the blight had almost run its course and was not so apparent as on an adjacent garden where many of the bushes had been very lightly picked in order to save them. In the one garden all the leaf that the blight could attack had been constantly removed while in the other the saved bushes contained the very kind of leaf the blight required.

The drawback to this method of close picking is that it is practicable only in the latter part of the season after good growth has been made in the earlier part of the year, but would be dangerous after a period of unfavourable growth at the opening of the growing season. A drawback planters urge against this method is that it takes a very strong labour force to pick over a garden in the time, and in most gardens in the Darjeeling district at the present time this is said not to be available in the busy season. If a garden was in vigorous health and flushing well they maintain it could not be overtaken in time, for even with the ordinary way of picking it is sometimes difficult to get round. But under this method of close picking a longer time ultimately would elapse between successive pickings. This indeed is the line of work most likely to turn out a feasible method of dealing with the blight in the rains. It is an investigation beyond the power of a man at a distance to undertake. It must be done by a man who knows intimately the practical methods of tea garden culture and can stay for fairly long periods on the affected gardens.

Spraying.—It was demonstrated at Tukvar in a number of small experiments that spraying with Bordeaux Mixture kills the spores and filaments of the fungus, where the liquid comes in contact with them, thus keeping down the spread of the disease and saving the unaffected parts of the leaf for the use of the bush. It also does much good on young green twigs affected with blight. In the usual course of the disease when a twig becomes "blistered" the swelling extends gradually round and through the twig and ultimately causes the part above the spot to succumb. If, however, it is sprayed before the spot has extended much, then the Bordeaux Mixture kills the fungus, the shoot recovers, and the buds flush. This in itself is a great advantage as it saves the buds in the axils of the leaves above the affected spot to produce leaf for tea. The mixture on the leaves also prevents the spores that fall on them from developing.

As spore-formation usually and infection invariably takes place on the under surface of the leaf this is the side that must be sprayed. That, accordingly, makes spraying difficult as the tea bushes are very dense. It was also found difficult to get coolies to spray properly. The nozzle of the sprayer had to be inserted into the bush and so manipulated that the under sides of the leaves were thoroughly treated. They always wanted to spray from above and the lower young twigs on a bush were often missed. However with patience and by always employing the same men to spray they improved wonderfully. The Bordeaux Mixture used was that indicated by the formula (6-4-50), 6 lbs. of copper-sulphate, 4 lbs. of unslaked lime and 50 gallons of water. It was made in the way usually recommended, with observation of the necessary precautions and tests. Full directions were given to the garden managers at the time but they need not be repeated here. Besides Bordeaux Mixture experiments were made with potassium sulphide, formalin, kerosene and water, salt, woodash dry and in watery solution and "Bordeaux powder". All of them kill the white blisters, which indeed are not difficult to kill, but none of them kill the fungus in incipient blisters. A fungicide that would do that would kill the leaf tissues also. There seems a fair chance of "Bordeaux powder" being useful in this way, if an easy and efficient way of dusting it could be found. The experiments with all these were not conclusive enough to warrant the publication of results but when opportunity occurs this enquiry will be extended. In this connection I wish specially to thank Messrs. Claud Bald and A. Shannon both of whom were very keenly interested in the discovery of a blight remedy and made many and varied experiments to this end.

Spraying on tea gardens, situated as they are on steep slopes of the hill sides, is an arduous task. The chief difficulties in the way are due to heavy rainfall and to the difficulty of transporting water for preparing the fungicide. During the time when blister blight is spreading the heavy and frequent showers wash off the liquid sprayed on the leaves, especially on the high gardens about the mist zone where it is often continuously wet for days together. The fungicide does not remain on the leaf long enough to prevent incipient blisters from developing. It has no effect on new shoots that develop after the application and they are just as ready to be infected unless spraying is repeated for their benefit. General spraying therefore in the rains is

out of the question. But on heavy pruning, new extension and seed-beds where the area is usually small and the blight might cause heavy loss for more than one year, the labour and expense of repeated spraying might be well repaid by the saving of the plants. For instance at Tukvar a small block of heavy pruning became well blighted in June and July. It was sprayed with Bordeaux Mixture five times and in September looked very well, though it never became quite free from blight; a few blisters could be found here and there. The bushes were all healthy and made good growth. The manager was well satisfied that the result was worth the effort made. This block suffered little in comparison with other affected heavy pruned blocks that had not been treated in any way. Spraying, in such cases, to do good must be repeated. Once only is not enough. Buds that open after the bush has been sprayed are unprotected by the fungicide and are liable to fresh infection and have to be covered with fungicide. It will be seen that spraying under such circumstances is in general impracticable and can be done only to avert anticipated heavy or total loss in these three special kinds of blocks.

Pruning.—For this one cold weather, all bushes should be pruned in the ordinary way back to the last one or two buds and the lower as well as the upper parts of the bush should receive attention. As it is possible and very probable that unpruned tea carries over the blight from the end of one season to the beginning of the next, it is strongly to be recommended that this winter, no tea be left unpruned. Stick-pruning is not practised in this hill district and some leaves are always left on pruned bushes. At the period of pruning all old leaves with traces of old blisters should be removed and as the matter is too important to be left to the discrimination of the ordinary coolie, the order should be to remove all spotted leaves. From November to March in Darjeeling actual tea-making operations are suspended hence more labour is available then than during the rains for work on the garden. As pruning is the most important work to be done at this time, the careful removing during the operation of all leaves that showed signs of having had blister blight will not add unduly to the heaviness of the work. Then is the most favourable opportunity of dealing with the blight and again in March when the blight is likely to become active as the air becomes moisture laden before the coming of the early rains. During the cold weather observations should be made to see whether the blight may not

harbour on these few leaves left on bushes after pruning and if living blisters be found after November a note might be made in the garden records and the leaves with the living blisters sent to the President of the Association.* Prunings from blighted bushes ought by no means to be left on the ground nor should cultivation alone be relied on to get rid of them. It is not sufficient simply to turn them in during cultivation. All prunings or at any rate all from affected areas should be buried or burned and with careful cultivation following, all the fallen leaves and twigs will be turned in and rendered harmless. Heavy pruned tea suffers severely and whether the leaves are picked off or left blistered on the bush an attack often means disaster. Hence as little as possible heavy pruning should be done this autumn and when it must be done, care should be exercised in selecting a plot to be heavily pruned that it is not very near a plot that was badly affected.

During the early months of 1910 a careful look out should be kept for the first appearance of blister. This is the time when vigilance and energy in dealing with the blight will produce results. Whenever seen the blistered leaves should be destroyed and the bushes all round should be sprayed thoroughly with Bordeaux Mixture, and coolies sent round to pick any leaves with fresh blisters that may have escaped treatment. Keep on with the treatment till the early rains come. If blister blight be not eradicated from tea this cold weather, it may continue to spread and then it is unlikely that it will ever be entirely banished and there will always be the danger, when conditions are favourable, of its reappearing in force.

Recommendations that were made for the cold weather of 1909-10:—
It would be advisable—

To prune all bushes in the garden. The pruners might open up the bushes and remove all growth-leaf showing traces of having been blistered.

To leave no tea unpruned and to do no top-pruning (skiffing).

To attempt heavy pruning with caution and to restrict the area as far as possible. It might be done comparatively early to get some growth in spring before the blight may appear.

* On the 25th of December the President sent me two fresh, blistered tea leaves. Both conidia (two-celled spores) and basidio-spores (one-celled spores) were present and both germinated readily, when placed on a moist glass slide. There seems to be no question that the blight lives on in a state of reduced vigour through the cold weather. This renders carefulness during pruning of the utmost importance.

To burn all prunings or at least those from affected blocks or to bury them in the bottom of trenches under at least 1½ feet of earth.

To have a responsible assistant go carefully over every block to see that affected stems and leaves were left neither on the bushes nor exposed on the ground.

To begin pruning early in the cold weather and to cultivate soon afterwards in order that any blighted leaves or twigs on the ground might be forked in.

A strenuous effort should be made in every garden in the whole district. Success in exterminating the blight depends on whole-hearted co-operation.

If blister blight should appear on a bush at the beginning of the season of 1910, pick off the blistered leaves a tonce and spray this and surrounding bushes with Bordeaux Mixture and this may be done till the early rains come.

In seed-beds, new extension and heavy pruning, where the damage from blister blight may be considerable, be prepared to expend money on repeated application of blight remedies should the blight appear. The benefit in each case would more than pay for the cost of treatment. Jungle trees near tea might be thinned and branches lopped off shade trees that have become too dense.

With such treatment this cold weather there is reason to hope that the blight will be thoroughly checked, if not completely eradicated from the tea.

Publications dealing with Blister Blight.

1. Watt, G. "Pests and Blights of the Tea Plant." 1898.
2. Massee, G. "Tea Blights." *Kew Gardens Bulletin.* 1898.
3. Watt, G., and Mann., H. H. "Pests and Blights of the Tea Plant". Second Edition, 1898.
4. Mann, H. H. "The Blister Blight of Tea". *Ind. Tea Assoc., Bull. 3*, 1906.

PLATE II.

FIG. 1.—Shoot of Tea showing the upper part bending over at the affected spot on the stem.

FIG. 2.—Upper side of a blistered leaf showing the concave spots. From a photograph.

FIG. 3.—Under side of a blistered leaf showing the convex spore-covered surface. From a photograph.

PLATE II

Fig. 1

Fig. 2.

Fig. 3

Blister Blight of Tea.

PLATE III.

Tea bush affected by Blister Blight. From a photograph by Mr. Claud Bald, Tukvar. The surrounding bushes have been blocked from the back-ground.

PLATE III.

Tea Bush affected by Blister Blight.

PLATE IV.

Exobasidium on khasiana Symplocos Theæfolia D. Don.

PLATE IV.

EXOBASIDIUM ON SYMPLOCOS THEIFOLIA.

PLATE V.

FIG. 1.—Transverse section through part of a leaf of Tea with a young blister. ×200.

FIGS. 2 and 3.—Germ tubes from conidia entering the stomata. ×800.

FIG. 4.—Under surface of leaf of Tea with hyphæ entering a stoma. ×610.

FIG. 5.—Section showing hyphæ approaching a stoma. ×610.

FIG. 6.—Same showing stoma being burst. ×610.

FIG. 7.—Section showing hyphæ bursting the epidermis not under a stoma, and the isolation of the cells of the host plant by the mass of hyphæ. 610.

PLATE V.

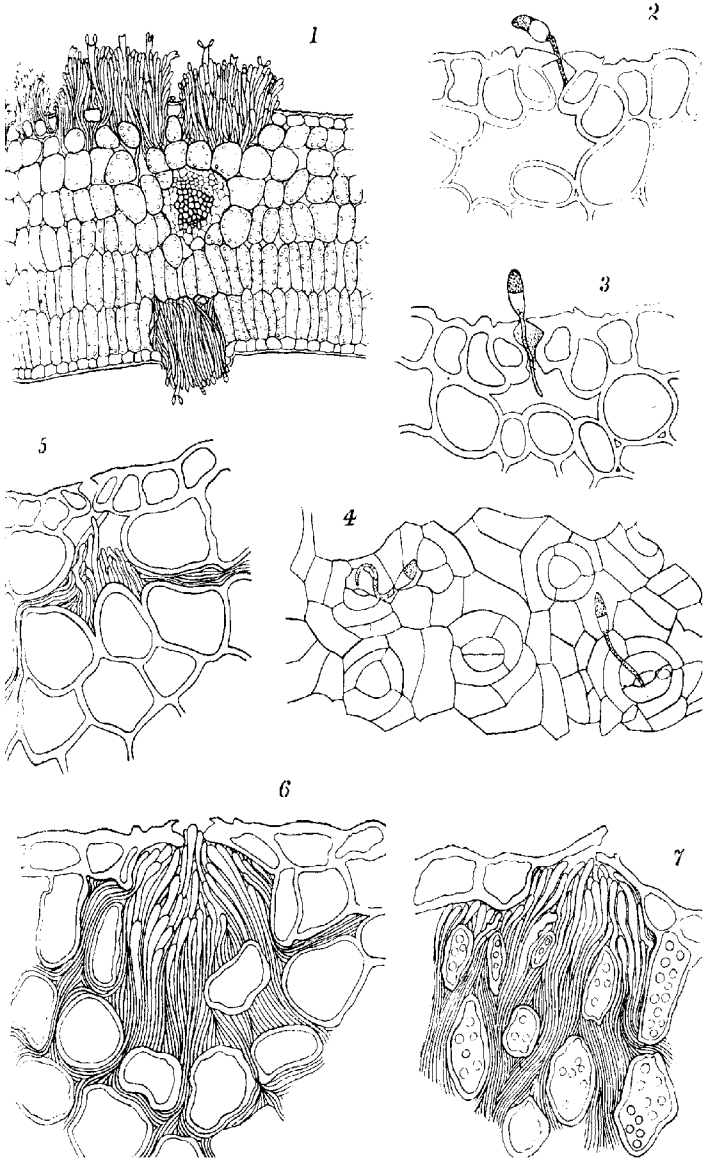

PLATE VI.

FIG. 1.—Transverse section through a part of a young blister. ×610.
FIGS. 2 and 3.—Germinating conidia. ×610.
FIG. 4.—Conidia. ×610 and ×800.
FIG. 5.—Section of leaves showing the depth of the blisters.
FIG. 6.—Basidia bearing basidiospores. ×800.
FIG. 7.—Formation of conidium. ×610.

PLATE VI.

EXOBASIDIUM VEXANS.

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